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THE Be-Pt (BERYLLIUM-PLATINUM) SYSTEM

H. Okamoto
L. E. Tanner

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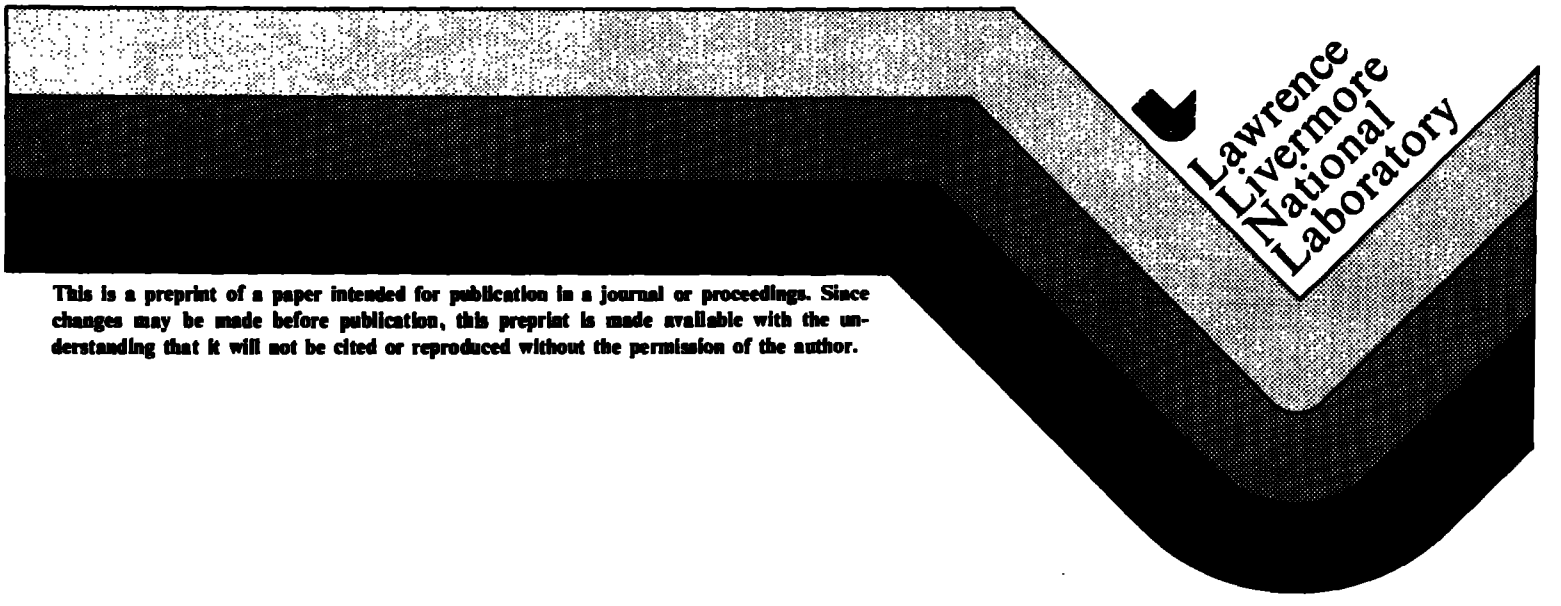

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By H. Okamoto and L.E. Tanner

Lawrence Livermore National Laboratory

Equilibrium Diagram

Available information on the Be-Pt phase diagram is fragmentary as is shown in Fig. 1. Intermediate phases reported in the literature thus far are: (1) $Be_{12}Pt$ ($Mn_{12}Th$-type); (2) Be_5Pt ($AuBe_5$-type); (3) $Be_{21}Pt_5$ (Ni_5Zn_{21}-type); (4) BePt (CsCl-type); and (5) $BePt_{15}$ (?). Of these, the latter three may need further examination for confirmation. Assessment is based on comparisons with the Be-Pd system [85Oka] which shows certain similarities.

Liquidus. No experimental data are available. Assuming that (1) the solid solubility range of (Pt) phase is restricted up to the melting point as in the (Pd) phase in Be-Pd phase diagram [85Oka] and (2) the thermodynamic properties of liquid Be-Pt are similar to that of Be-Pd, then the Pt-end of the L/[L+(Pt)] liquidus can be estimated. However, using the similar approach for the L/[L+(αBe)] liquidus is not as reliable because the (αBe) phase may have a sizable solubility range at high temperatures (>1200 °C) as can be projected from the solubility data in Table 1.

(βBe) and (αBe) Terminal Solid Solutions. The melting point of (βBe) and the (βBe) --> (αBe) allotropic transformation temperature are 1289±4 and 1270±6 °C, respectively [85BAP]. [61Pic] reported that Pt may dissolve appreciably in (βBe) but he did not give values. The solubility limit of Pt in (αBe) has been reported as given in Table 1.

(Pt) Terminal Solid Solution. The melting point of Pt is 1769.0 °C [Melt]. The reported solubility limit of Be in Pt is listed in Table 2.

Intermediate Phases. The existence of the two Be-rich phases, $Be_{12}Pt$ and Be_5Pt, seem to be well established by XRD studies of single crystals and powders [58Bat] (see Table 3). The latter phase is likely to have some homogeneity range because of

observed variations in lattice parameters (Table 3) [58Bat]. [59Pai] reacted powders of $Be_{13}Pt$ and Be_5Pt at 1400 °C in vacuum and obtained ambiguous results, but these may be interpreted as further confirmation for Be_5Pt, based on his finding a cubic phase with a = 0.6003 nm. Diffusion couple measurements by [75Mat] suggested that a phase exists with up to 60 wt.% Pt (6.5 at.% Pt) and is stable at 1000 and 1100 °C but unstable at 900 °C. This phase would appear to correspond to $Be_{12}Pt$. In addition, [75Mat] found two other distinguishable phases having compositions 85 to 87 wt.% Pt (20.7 to 23.6 at.% Pt) and 93 to 94 wt.% Pt (38 to 42 at.% Pt); the former was believed to correspond to $Be_{21}Pt_5$ (19.2 at.% Pt).

The $Be_{21}Pt_5$ phase was identified as having a deformed γ brass-type structure by [35Mis] and this was supported by [54Bok], but lattice parameters were not reported in either paper. [75Mat] gave solubility ranges as a function of temperature for this phase as follows:

Temperature, °C	Range, wt.% Pt (at.% Pt)
1100	85 to 87 (20.7 to 23.6)
1000	85 to 86 (20.7 to 22.1)
900	85 (20.7)

Further study here is required.

[59Pai] also reacted an equiatomic powder mixture at 1400 °C and found a cubic phase with a = 0.280 nm. He compared it to BePd (i.e. B2, CsCl-type) and this agrees with the prediction of structure type and lattice parameter of [80Tan].

Diffusion couple measurements by [75Mat] revealed a phase consisting of 42 at.% Pt at 900 °C and 38 at.% Pt at 1000 °C. No corresponding phase has been reported in this composition range.

Crystal Structures

Available data on crystal structures are summarized in Table 3.

Thermodynamics

No information is available on the thermodynamic properties of Be-Pt alloys. In order to attempt an estimate of the liquidus near the melting point of Pt, the following assumptions have been made: (1) the (Pt) phase has no solubility range; (2) the lattice stability parameter of solid Pt is given as -19690 + 9.623T J/mol (reference state the liquid), based on the heat of fusion given by [83Cha]; and (3) the Be-Pt liquid behaves almost like Be-Pd liquid [85Oka] (G^{ex} = -100X(1-X) kJ/mol). Fig. 1 shows the calculated liquidus based on these assumptions as well as that from the ideal solution model for comparison. This calculated liquidus is probably not very much different from the actual liquidus near the melting point of Pt.

General References

[Hansen]: M. Hansen and K. Anderko, Constitution of Binary Alloys, McGraw-Hill, New York or General Electric Co., Business Growth Services, Schenectady, NY 12345 (1958)

[Elliott]: R.P. Elliott, Constitution of Binary Alloys, First Supplement, McGraw-Hill, New York or General Electric Co., Business Growth Services, Schenectady, NY 12345 (1965)

[Shunk]: F.A. Shunk, Constitution of Binary Alloys, Second Supplement, McGraw-Hill, New York or General Electric Co., Business Growth Services, Schenectady, NY 12345 (1969)

[Pearson]: W.B. Pearson, Handbook of Lattice Spacings and Structures of Metals and Alloys, Vol. 1 (1958) and Vol. 2 (1967), Pergamon Press, New York

[Hultgren, E]: R. Hultgren, P.D. Desai, D.T. Hawkins, M. Gleiser, K.K. Kelley, and D.D. Wagman, Selected Values of the Thermodynamic Properties of the Elements, American Society for Metals, Metals Park, OH (1973)

[Hultgren, B]: R. Hultgren, P.D. Desai, D.T. Hawkins, M. Gleiser, and K.K. Kelley, Selected Values of the Thermodynamic Properties of Binary Alloys, American Society for Metals, Metals Park, OH (1973)

[Melt]: "Melting Points of the Elements", Bull. Alloy Phase Diagrams, 2(1), 145-146 (1981)

[King1]: H.W. King, "Crystal Structures of the Elements at 25 °C", Bull. Alloy Phase Diagrams, 2(3), 401-402 (1981)

[King2]: H.W. King, "Temperature-Dependent Allotropic Structures of the Elements", Bull. Alloy Phase Diagrams, 3(2), 275-276 (1982)

Specific References

35Mis: L. Misch, "Structure of Intermetallic Compounds of Beryllium with Copper, Nickel and Iron," Z. Phys. Chem., B29, 42-58 (1935) in German. (Equi Diagram; Experimental)

41Fro: K.W. Frohlich, "Substitution of Indium and Other Platinum Metals by Beryllium," Degussa Metallber., 114-135; abstract in [Gmelins], No. 68A(6), 748-749 (1941)in German. (Equi Diagram; Experimental)

48Nem: V.A. Nemilov and A.A. Rudnitskii, "Alloys of Platinum with Beryllium," Izv. Sektora Platiny i Drugikh Blagorodnykh Metallov., Inst. Obshchei i Neorg. Khim, Akad. Nauk, USSR, 21, 239-241 (1948) in Russian. (Equi Diagram; Experimental), as cited in [51Ric]

50Kau: A.R. Kaufmann, P. Gordon, and D.W. Lillie, "The Metallurgy of Beryllium," Trans. ASM, 42, 785-844 (1950). (Equi Diagram; Experimental)

51Ric: J.T. Richards, "A Review of Beryllium and Beryllium Alloys," J. Metals, 3(5), 379-386 (1951). (Equi Diagram; Review)

54Bok: G.B. Bokii, Vvedenie v Kristallokhimiyu, 298, Izdatel. Moskov. Univ., Moscow (1954) in Russian. (Equi Diagram; Experimental); quoted by A.E. Vol, Constitution and Properties of Binary Metallic Systems, vol. I, 640, Gosudarst. Izdatel., Moscow (1959) in Russian

*58Bat: F.W. von Batchelder and R.F. Raeuchle, "The Tetragonal MB_{12} Structure of Silver, Palladium, Platinum and Gold," Acta Crystallogr., 11(2), 122 (1958). (Equi Diagram, Crys Structure; Experimental)

*59Pai: R.M. Paine, A.J. Stonehouse, and W.W. Beaver, "An Investigation of Intermetallic Compounds for Very High Temperature Applications," WADC Tech. Rept., part. I (1959).

(Equi Diagram, Crys Structure; Experimental)

61Pic: J.J. Pickett, E.D. Levine, and W.B. Nowak, "Stability of the High Temperature β-phase in Beryllium and Beryllium Alloys," U.S. At. Energy Comm. NMI-1252, 34pp (1961). (Equi Diagram; Experimental)

62Bro: W. Bronger and W. Klemm, "Preparation of Alloys of Platinum with Base Metals," Z. Anorg. Chem., 319(1/2), 58-81 (1962) in German. (Crys Structure; Experimental)

*75Mat: M.P. Matveyeva, R.M. Volkova, I.D. Marchukova, and A.E. Mirkin, "An Investigation of Diffusion in the Pt-Be System," Izv. Akad. Nauk SSSR, Met., (5), 196-202 (1975) in Russian; TR: Russ. Met., (5), 156-160 (1975). (Equi Diagram; Experimental)

80Tan: L.E. Tanner, "The Stable and Metastable Phase Relations in the Hf-Be Alloy System," Acta Metall., 28(12), 1805-1816 (1980). (Equi Diagram; Theory)

83Cha: M.W. Chase, "Heats of Transformation of the Elements," Bull. Alloy Phase Diagrams, 4(1), 123-124 (1983). (Thermo; Compilation)

85BAP: to be published in Bull. Alloy Phase Diagrams (1985). (Equi Diagram; Compilation)

85Oka: H. Okamoto and L.E. Tanner, "The Be-Pd (Beryllium-Palladium) System," to be published in Bull. Alloy Phase Diagrams (1985). (Equi Diagram, Thermo; Review)

* Indicates key paper.

Acknowledgements

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Table 1 Solubility Limit of Pt in (α Be)

Reference	Composition, at.% Pt	Comments
50Kau	<1.1	...
75Mat	0.63 at 1200°C	decreases with decreasing temperature

Table 2 Solubility Limit of Be in (Pt)

Reference	Composition, at.% Be	Comments
41Fro	1.28	...
48Nem	5.15	could be 3.15 at.% Be [Hansen]
75Mat	0.86 to 1.07	unchanged between 900 and 1100°C

Table 3 Be-Pt Crystal Structure and Lattice Parameter Data

Phase	Composition range, at.% Pt	Pearson symbol	Strukturbericht designation	Space group	Prototype	Lattice parameters, nm a	c	Reference
(βBe)....	0 to ?	cI2	A2	Im3m	W	0.25515	...	[King2]
(αBe)....	~0(a)	hP2	A3	$P6_3/mmc$	Mg	0.22857	0.35839	[King1]
$Be_{12}Pt$....	7.7	tI26	$D2_b$	I4/mmm	$Mn_{12}Th$	0.7237	0.4252	[58Bat]
Be_5Pt....	16.7	cF24	$C15_b$	$F\bar{4}3m$ or F23	$AuBe_5$	0.6004 to 0.5978	...	[58Bat]
$Be_{21}Pt_5$?..	19.2	Cubic	$D8_{1-3}$	?	Ni_5Zn_{21}	?	...	[54Bok]
BePt.....	50	cP2	B2	Pm3m	CsCl	0.280	...	[59Pai, 80Tan]
$BePt_{15}$?...	93.8	(hexagonal)		?	?	2.213	2.712	[62Bro]
(Pt)...	~100(b)	cF4	A1	Fm3m	Cu	0.39233	...	[King1]

(a) See Table 1. (b) See Table 2.

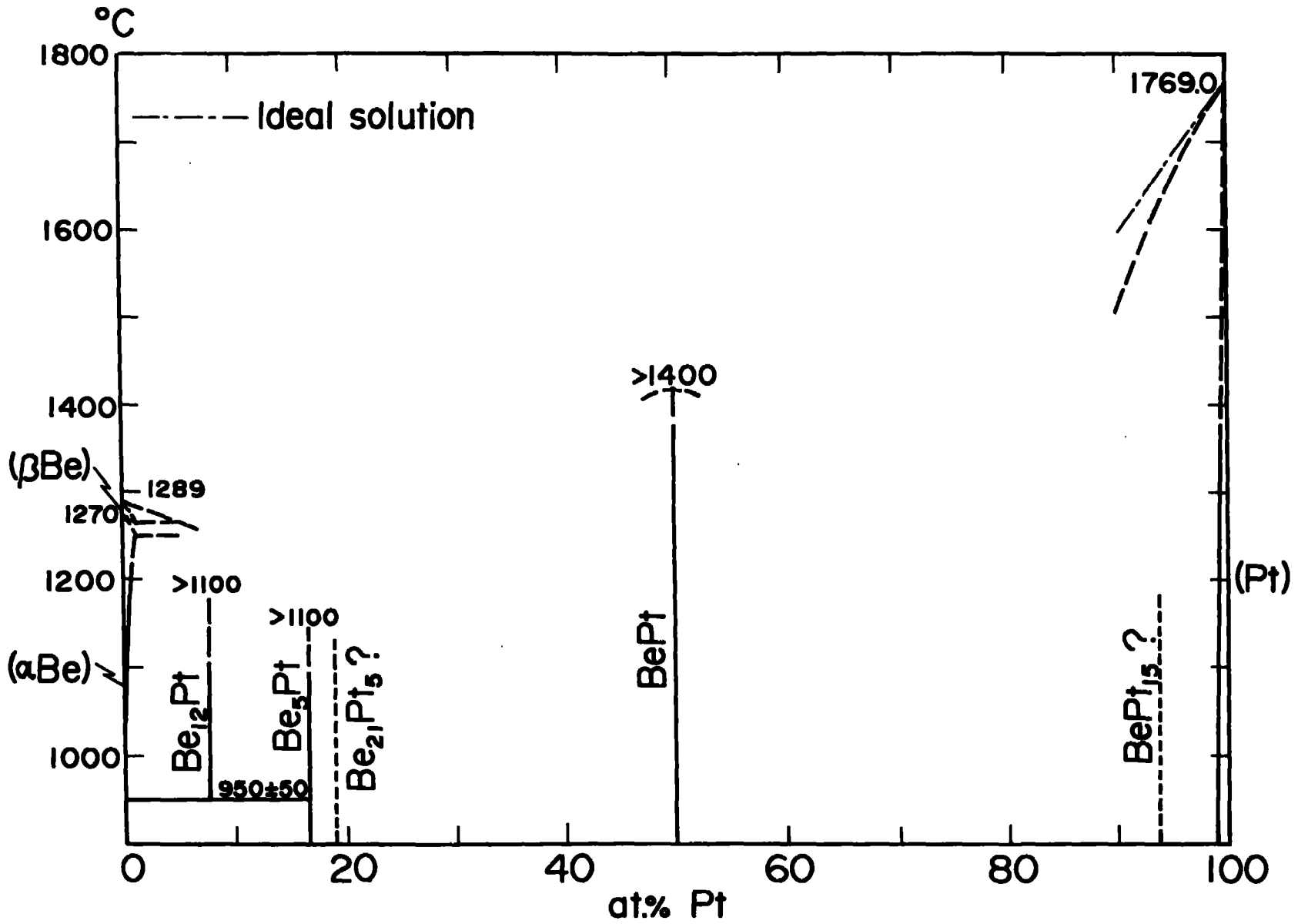
°C
1800
1600
1400
1200
1000
Ideal solution
1769.0
>1400
(βBe)
1289
1270
(αBe)
>1100
>1100
Be12Pt
Be5Pt
Be21Pt5?
BePt
BePt13?
(Pt)
950±50
0
20
40
60
80
100
at.% Pt

Fig. 1